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[Title of Article] Claims 1

[Title of Article] Specification 1

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[Title of Article] Abstract 1

[Number of General Power] 0 2 1 2 9 4 9

[Kind of Document] Claims

[Claim 1]

An organic light-light conversion device comprising a light sensing unit having a layer including 5 a photo-conductive organic semiconductor that causes a photo-current multiplication phenomenon by light irradiation, and a light emitting unit having a layer including an electroluminescent organic semiconductor that emits light by current injection, characterized in 10 that at least one of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor is a polymer semiconductor.

[Claim 2]

The organic light-light conversion device 15 according to claim 1, characterized in that the photo-conductive organic semiconductor is a polymer semiconductor.

[Claim 3]

The organic light-light conversion device 20 according to claim 1, characterized in that the electroluminescent organic semiconductor is a polymer semiconductor.

[Claim 4]

The organic light-light conversion device 25 according to any of claims 1 to 3, characterized in that the photo-conductive organic semiconductor and the electroluminescent organic semiconductor are polymer semiconductors.

[Claim 5]

The organic light-light conversion device according to any of claims 1 to 4, characterized by comprising:

- 5 a) a light sensing unit having a layer including the photo-conductive organic semiconductor,
- b) a light emitting unit having a layer including the electroluminescent organic semiconductor placed on a different location from the light sensing
- 10 unit on the same substrate, and
- c) a conductive layer connecting the light sensing unit to the light emitting unit laid on the same substrate.

[Claim 6]

15 The organic light-light conversion device according to claim 5, characterized in that a light shielding member is provided between the light sensing unit and light emitting unit.

[Claim 7]

20 The organic light-light conversion device according to claim 5, characterized in that a translucent member having a transmittance that suppresses but does not completely shield the flow of feedback light into the light sensing unit is provided
25 between the light sensing unit and the light emitting unit.

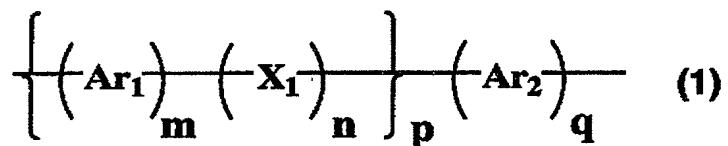
[Claim 8]

The organic light-light conversion device

according to any of claims 1 to 4, characterized in that the light sensing unit having a layer including the photo-conductive organic semiconductor is integrally laminated with the light emitting unit having a layer 5 including the electroluminescent organic semiconductor.

[Claim 9]

The organic light-light conversion device according to any of claims 1 to 8, characterized in that the polymer semiconductor contains one or more repeating 10 units represented by the following Formula (1) :



wherein Ar_1 and Ar_2 each independently represent an arylene group or a divalent heterocyclic group; X_1 represents $-\text{CR}_1=\text{CR}_2-$, $-\text{C}\equiv\text{C}-$ or $-\text{N}(\text{R}_3)-$; R_1 and R_2 each independently represent a hydrogen atom, an alkyl group, 15 an aryl group, a monovalent heterocyclic group, a carboxyl group, a substituted carboxyl group or a cyano group; R_3 represents a hydrogen atom, an alkyl group, an aryl group, a monovalent heterocyclic group, an arylalkyl group or a substituted amino group; m , n and q 20 represent an integer of 0 or 1; p represents an integer of 0 to 2; and $m + n$ and $p + q$ are each 1 or more, provided that Ar_1 , X_1 , R_1 , R_2 and R_3 , if they are each multiple, can be respectively identical or different,

and has a polystyrene-converted number average molecular weight of 1×10^3 to 1×10^8 .

[Claim 10]

The organic light-light conversion device
5 according to any of claims 1 to 9, characterized in that
the layer including the photo-conductive organic
semiconductor and/or the layer including the
electroluminescent organic semiconductor contains two or
more polymer semiconductors containing one or more
10 repeating units represented by Formula (1).

[Claim 11]

An image intensifier characterized by
comprising a plurality of the organic light-light
conversion devices according to any of claims 1 to 10
15 arranged.

[Claim 12]

A light sensor characterized by comprising the
organic light-light conversion device according to any
of claims 1 to 10, and a means to measure and output a
20 voltage applied to both ends of the layer including the
electroluminescent organic semiconductor.

[Kind of Document] Description

[Title of the Invention] ORGANIC LIGHT-LIGHT CONVERSION
DEVICE

[Technical Field]

5 [0001]

The present invention relates to an organic
light-light conversion device.

[Background Art]

[0002]

10 It has been known that a phenomenon wherein a
photo-current generated by a larger number of electrons
than the number of incident photons is observed (photo-
current multiplication phenomenon) when a layer composed
of a photo-conductive organic semiconductor is contacted
15 to a conductive layer composed of a material different
from the photo-conductive organic semiconductor (such as
a metal and an organic semiconductor) (referred to as
heterogeneous material layer), and the layer composed of
a photo-conductive organic semiconductor is irradiated
20 by light while applying a voltage (refer to M. Hiramoto,
T. Imahigashi and M. Yokoyama: Applied Physics Letters,
Vol. 64 187 (1994) and JP-A-2002-341395).

[0003]

This is a phenomenon wherein holes are
25 accumulated in a photo-conductive organic semiconductor
in the vicinity of the boundary between the layer

composed of the photo-conductive organic semiconductor and the heterogeneous material layer by light irradiation, and a large amount of electrons are injected by tunneling from the heterogeneous material 5 layer into the photo-conductive organic semiconductor by the high electric field formed by the holes. (An element having a combination of a layer composed of a photo-conductive organic semiconductor and a heterogeneous material layer using such a phenomenon is herein 10 referred to as a photo-current multiplication element.)

[0004]

As a device to which a photo-current multiplication element is applied, there has been known an organic light-light conversion device having a light 15 sensing unit having a layer including a photo-conductive organic semiconductor that causes a photo-current multiplication phenomenon by light irradiation (photo-current multiplication layer), and a light emitting unit having a layer including an electroluminescent organic 20 semiconductor that emits light by current injection (organic EL light emitting layer).

In such a device, although light is emitted from the light emitting unit by radiating light to the light sensing unit, the light is amplified by radiated 25 light, and the wavelength thereof can be the same as or different from the wavelength of the radiated light.

[0005]

As examples of such organic light-light

conversion devices, there has been known a device wherein a light sensing unit having a layer including a photo-conductive organic semiconductor and a light emitting unit having a layer including an 5 electroluminescent organic semiconductor are integrally laminated on the same substrate (Non-Patent Document 1), and a device wherein a light sensing unit having a layer including a photo-conductive organic semiconductor and a light emitting unit having a layer including the above- 10 described organic electroluminescent body placed on a location different from the location of the light sensing unit on the same substrate (Non-Patent Document 2).

[0006]

15 Both the photo-conductive organic semiconductor and the electroluminescent organic semiconductor used in the photo-current multiplication layer and an organic EL light emitting layer in these devices were low-molecular-weight compound, such as 20 organic pigments, and these were used alone or by dispersing in a resin in these layers.

[Non-Patent Document 1] "Applied Physics", Vol. 64 (1995), 1036

[Non-Patent Document 2] 49th Lecture Meeting of Japan 25 Society of Applied Physics, 28p-M-10
[Disclosure of Invention]
[Problem to be solved by the Invention]
[0007]

The above-described organic light-light conversion device using a low-molecular-weight compound as a photo-conductive organic semiconductor and an electroluminescent organic semiconductor had problems 5 wherein short-circuiting occurred easily because pinholes were easily produced in the photo-current multiplication layer and the organic EL light emitting layer, and when a resin containing a dispersed low-molecular-weight compound was used, the low-molecular-10 weight compound aggregated easily; and in any case, the device characteristics were still insufficient.

[0008]

It is an object of the present invention to provide an organic light-light conversion device that 15 excels in device characteristics.

[Means for Solving the Problem]

[0009]

As a result of extensive studies to solve the above-described problems, the present inventors have 20 found that an organic light-light conversion device that excels in device characteristics can be obtained by substituting at least one of a photo-conductive organic semiconductor and an electroluminescent organic semiconductor by a polymer semiconductor, and completed 25 the present invention.

[0010]

Specifically, the present invention provides an organic light-light conversion device comprising a

light sensing unit having a layer including a photo-conductive organic semiconductor that causes a photo-current multiplication phenomenon by light irradiation, and a light emitting unit having a layer including an

5 electroluminescent organic semiconductor that emits light by current injection, characterized in that at least one of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor is a polymer semiconductor.

10 [Advantages of the Invention]

[0011]

The organic light-light conversion device of the present invention excels in device characteristics, such as light-light conversion efficiency.

15 [Best Mode for Carrying Out the Invention]

[0012]

The organic light-light conversion device of the present invention is an organic light-light conversion device comprising a light sensing unit having

20 a layer including a photo-conductive organic semiconductor causing a photo-current multiplication phenomenon by light irradiation, and a light emitting unit having a layer including an electroluminescent organic semiconductor emitting light by current

25 injection, characterized in that at least one of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor is a polymer semiconductor.

[0013]

An embodiment of an organic light-light conversion device of the present invention is:

(A) an organic light-light conversion device
5 including a light sensing unit having a layer including a photo-conductive organic semiconductor, and a light emitting unit having the above-described electroluminescent organic semiconductor placed on the location different from the light sensing unit on the 10 same substrate, wherein at least one of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor is a polymer semiconductor.

In this case, the light sensing unit is
15 electrically connected to the light emitting unit through a conductive layer laid on the same substrate. The conductive layer laid on the substrate can cover the entire surface of the substrate, or can have a minimal size required for electrically connecting the light 20 sensing unit to the light emitting unit.

[0014]

In order to apply a voltage between the light sensing unit and the light emitting unit, an electrode is installed on the surface opposite to the substrate 25 side of the light sensing unit and/or the light emitting unit. The above-described heterogeneous material layer of the photo-current multiplication element (metallic layer) can be substituted by the conductive layer in the

substrate side, or can be substituted by the electrode on the opposite side.

[0015]

When light is made to be inputted or outputted to or from the electrode surface of the light sensing unit or the light emitting unit, an electrode that transmits light is used. When light is made to be inputted or outputted to or from the surface of the substrate side, a substrate and a conductive layer that transmit light are used. The electrode and the conductive layer that transmit light can be a transparent electrode and a conductive layer such as ITO, or a very thin metal electrode layer.

[0016]

When a voltage is applied between an electrode of the light sensing unit and an electrode of the light emitting unit, and light is radiated to the light sensing unit, electrons in the number not less than the number of incident photons are injected from the heterogeneous material layer (metallic layer) into the photo-current multiplication layer by the photo-current multiplication phenomenon. These charges are injected into the organic EL light emitting layer to emit light from the organic EL light emitting layer. Thereby the obtained outgoing light from the light emitting unit becomes amplified incident light.

[0017]

The above-described substrate is not

necessarily flat. For example, by using a curved substrate, the light incident axis can be inclined from the light emitting axis.

[0018]

5 Since the light sensing unit is independent from the light emitting unit, feedback light propagates to the exterior of the element. Therefore, the feedback light can be controlled by adjusting the distance between the light sensing unit and the light emitting 10 unit, or by installing a light shielding member between the light sensing unit and the light emitting unit. When importance is attached to the amplification of outgoing light, feedback light can be adjusted so as to be easily inputted into the photo-current multiplication 15 element; and when importance is attached to response to incident light, feedback light can be adjusted so that the feedback light is difficult to be inputted into the photo-current multiplication element.

[0019]

20 Another embodiment of an organic light-light conversion device of the present invention is (B) an organic light-light conversion device wherein a light sensing unit having a layer including a photo-conductive organic semiconductor is integrally laminated with a 25 light emitting unit having a layer including an electroluminescent organic semiconductor on the same substrate, and at least one of the photo-conductive organic semiconductor and the electroluminescent organic

semiconductor is a polymer semiconductor.

The configuration example is represented by Fig. 1. By radiating incident light 18 onto a photo-current multiplication layer 12, electrons are injected 5 from an electrode 13 to the photo-current multiplication layer 12 by the above-described photo-current multiplication phenomenon, and reach an organic EL light emitting layer 14. Thereby, the organic EL light emitting layer 14 emits light, and outgoing light 19 is 10 obtained. A hole transporting layer 15 supplies holes to bond with electrons when the organic EL light emitting layer 14 emits light, and is not essential in the present invention. A structure wherein the photo-current multiplication layer 12, the electrode 13, the 15 organic EL light emitting layer 14 and the hole transporting layer 15 are laminated in the reverse order from Fig. 1 is also feasible.

[0020]

Of the above-described embodiments (A) and 20 (B), (A) is preferable because the freedom of material selection of the light sensing unit and the light emitting unit is larger.

[0021]

Although the organic light-light conversion 25 device of the present invention is characterized in that at least one of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor is a polymer semiconductor, it is

preferable that both the photo-conductive organic semiconductor and the electroluminescent organic semiconductor are polymer semiconductors.

The polymer semiconductor used in the present invention can be selected so that the function of each of the light sensing unit and the light emitting unit wherein the polymer semiconductor is used is exerted; and the photo-conductive organic semiconductor and the electroluminescent organic semiconductor can be either same or different.

Since the wavelength of the light emitted from the light emitting unit is normally determined by the material used in the organic EL light emitting layer, the material used in the organic EL light emitting layer can be selected depending on the wavelength of the desired outgoing light.

[0022]

The organic light-light conversion device of the present invention is characterized in that not only the wavelengths of the incident light and the outgoing light are independently selected, but also the light-light conversion efficiency from the incident light to the outgoing light becomes 1 or more. The light-light conversion efficiency is defined by the value obtained by dividing the number of photons outputted as the outgoing light by the number of photons inputted as the incident light, and a high light-light conversion efficiency can be obtained by optimizing the combination

of the photo-conductive organic semiconductor and the electroluminescent organic semiconductor used in the organic light-light conversion device. The combination of the photo-conductive organic semiconductor and the 5 electroluminescent organic semiconductor wherein a light-light conversion efficiency of 10 times or more is obtained is preferable, 50 times or more is more preferable, and 200 times or more is especially preferable.

10 [0023]

When a polymer semiconductor is used as an electroluminescent organic semiconductor, an organic semiconductor other than polymer semiconductors can be used as a photo-conductive organic semiconductor.

15 Examples of such organic semiconductors include 3,4,9,10-perylenetetracarboxylic 3,4,9,10-bis(methylimide) (abbreviated as Me-PTC), 3,4,9,10-perylenetetracarboxylic 3,4,9,10-bis(phenylethylimide), 3,4,9,10-perylenetetracarboxylic dianhydride, imidazole 20 perylene, copper phthalocyanine, titanyl phthalocyanine, vanadyl phthalocyanine, magnesium phthalocyanine, non-metal phthalocyanine, naphthalocyanine, naphthalene, 2,9-dimethylquinacridone, unsubstituted quinacridone, pentacene, 6,13-pentacenequinone, 5,7,12,14- 25 pentacenetetrone, and derivatives thereof.

[0024]

When a polymer semiconductor is used as a photo-conductive organic semiconductor, a layer composed

of a polymer semiconductor and a layer composed of an organic semiconductor other than the above-described polymer semiconductor can be laminated and used. In this case, the thickness of the layer composed of an 5 organic semiconductor other than the polymer semiconductor is preferably smaller than the thickness of the layer composed of a polymer semiconductor.

[0025]

In addition, when a polymer semiconductor is 10 used as a photo-conductive organic semiconductor, an organic semiconductor other than the polymer semiconductor can also be used as an electroluminescent organic semiconductor. An example of such an organic semiconductor is aluminum-quinolinol complex 15 (abbreviated as "Alq₃").

[0026]

The light emitting unit having a layer including an electroluminescent organic semiconductor that emits light by current injection (organic EL light 20 emitting layer) can be composed of an organic EL light emitting layer alone. However, since light emitting in the organic EL light emitting layer is produced by the linkage of electrons supplied from the light sensing unit with holes in the organic EL light emitting layer, 25 a layer including a material to transport holes or electrons can be laminated on the organic EL light emitting layer as the light emitting part.

[0027]

As a material for transporting holes, for example, triphenyl diamine, 3,5-dimethyl-3,5-di-tert-butyl-4,4-diphenoxquinone, 2-(4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole, N,N,N',N'-tetra-(m-toluyl)-m-phenylenediamine, or derivatives thereof can be used.

[0028]

As the material for transporting electrons, for example, oxadiazole derivatives, anthraquinodimethane or derivatives thereof, benzoquinone or derivatives thereof, naphthoquinone or derivatives thereof, anthraquinone or derivatives thereof, tetracyanoanthraquinodimethane or derivatives thereof, fluorenone derivatives, diphenyldicyanoethylene or derivatives thereof, diphenoxquinone derivatives; or metal complexes of 8-hydroxyquinoline or derivatives thereof, polyquinoline or derivatives thereof, polyquinoxaline or derivatives thereof, or polyfluorene or derivatives thereof can be used.

[0029]

In order to facilitate the injection of holes or electrons, a hole injection layer or an electron injection layer can be laminated and used on the organic EL light emitting layer or the layer containing a material for transporting holes or electrons. Examples of the hole injection layer include: a layer containing a conductive polymer; a layer formed between the electrode of the hole-injection side (anode) and the

layer containing a material for transporting holes, and containing a material having an ionizing potential of a value intermediate between the anode material and the hole transporting material contained in the hole

5 transporting layer; and a layer formed between the electrode of the electron-injection side (cathode) and the layer containing a material for transporting electrons, and containing a material having an electron affinity of a value intermediate between the cathode

10 material and the electron transporting material contained in the electron transporting layer. In the case wherein the above-described hole-injection layer or electron-injection layer is a layer containing a conductive polymer, the electrical conductivity of the

15 conductive polymer is preferably 10^{-5} S/cm or more and 10^3 S/cm or less. In order to reduce the leakage current between devices when two or more organic light-light conversion devices are disposed in parallel, the electrical conductivity of the conductive polymer is

20 preferably 10^{-5} S/cm or more and 10^2 S/cm or less, and more preferably 10^{-5} S/cm or more and 10^1 S/cm or less.

In order to make the electrical conductivity of the conductive polymer 10^{-5} S/cm or more and 10^3 S/cm or less, adequate quantities of ions are normally doped 25 into the conductive polymer. The type of doped ions is anions for a hole-injection layer, and cations for an electron-injection layer. Examples of anions include polystyrene sulfonic ions, alkylbenzene sulfonic ions

and camphor sulfonic ions; and examples of cations include lithium ions, sodium ions, potassium ions, and tetrabutyl ammonium ions.

[0030]

5 The materials used in the above-described hole-injection layer or electron-injection layer can be adequately selected in relation to the materials for the electrodes or adjacent layers, and examples of such materials include conductive polymers, such as

10 polyaniline and derivatives thereof, polythiophene and derivatives thereof, polyphenylenevinylene and derivatives thereof, and polythienylenevinylene and derivatives thereof; metal phthalocyanine (such as copper phthalocyanine) and carbon.

15 [0031]

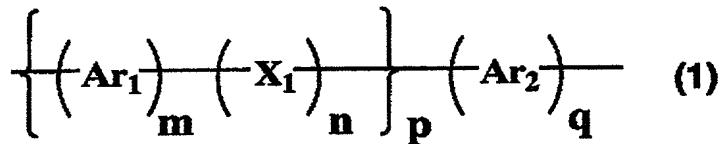
Next, the polymer semiconductor used in the present invention will be described.

As the polymer semiconductor used in the present invention, for example, a polymer semiconductor

20 having a π -conjugated group in the side chain, such as polyvinyl carbazole; a polymer semiconductor having a π -conjugation in the main chain, such as polyarylene and polyarylene vinylene; and a polymer semiconductor having a σ -conjugation in the main chain, such as polysilane.

25 Of these, the polymer semiconductor having conjugation in the main chain is preferable, the polymer semiconductor having a π -conjugation in the main chain is more preferable, and the polymer semiconductor having

at least one of repeating units represented by Formula (1) :



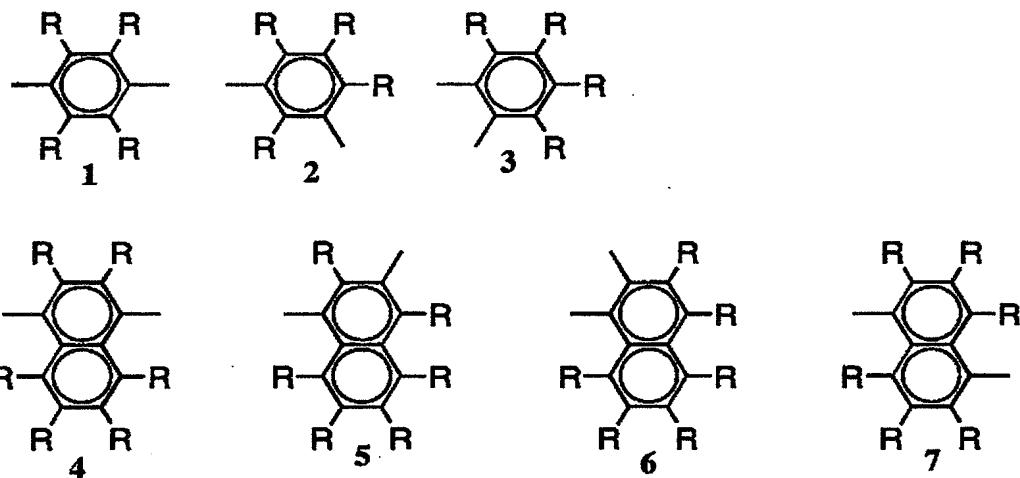
wherein Ar_1 and Ar_2 each independently represent an arylene group or a divalent heterocyclic group; X_1 represents $-\text{CR}_1=\text{CR}_2-$, $-\text{C}\equiv\text{C}-$ or $-\text{N}(\text{R}_3)-$; R_1 and R_2 each independently represent a hydrogen atom, an alkyl group, an aryl group, a monovalent heterocyclic group, a carboxyl group, a substituted carboxyl group or a cyano group; R_3 represents a hydrogen atom, an alkyl group, an aryl group, a monovalent heterocyclic group, an arylalkyl group or a substituted amino group; m , n and q represent an integer of 0 or 1; p represents an integer of 0 to 2; and $m + n$ and $p + q$ are each 1 or more, provided that Ar_1 , X_1 , R_1 , R_2 and R_3 , if they are each multiple, can be respectively identical or different, and having a polystyrene-converted number average molecular weight of 1×10^3 to 1×10^8 is more preferable.

[0032]

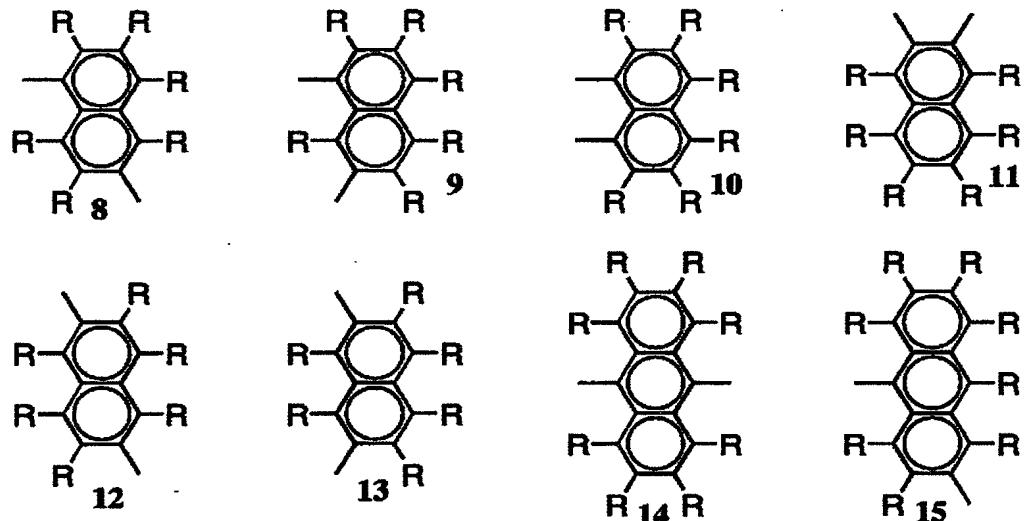
The specific examples of arylene groups in Ar_1 and Ar_2 in Formula (1) include phenylene groups (e.g. the following formulas 1 to 3), naphthalenediyl groups (the following formulas 4 to 13), anthracenylene groups (the following formulas 14 to 19), biphenylene groups (the

following formulas 20 to 25), triphenylene groups (the following formulas 26 to 28), and condensed cyclic compound groups (the following formulas 29 to 38). Of these, phenylene groups, biphenylene groups and 5 fluorene-diyl groups (the following formulas 36 to 38) are preferable.

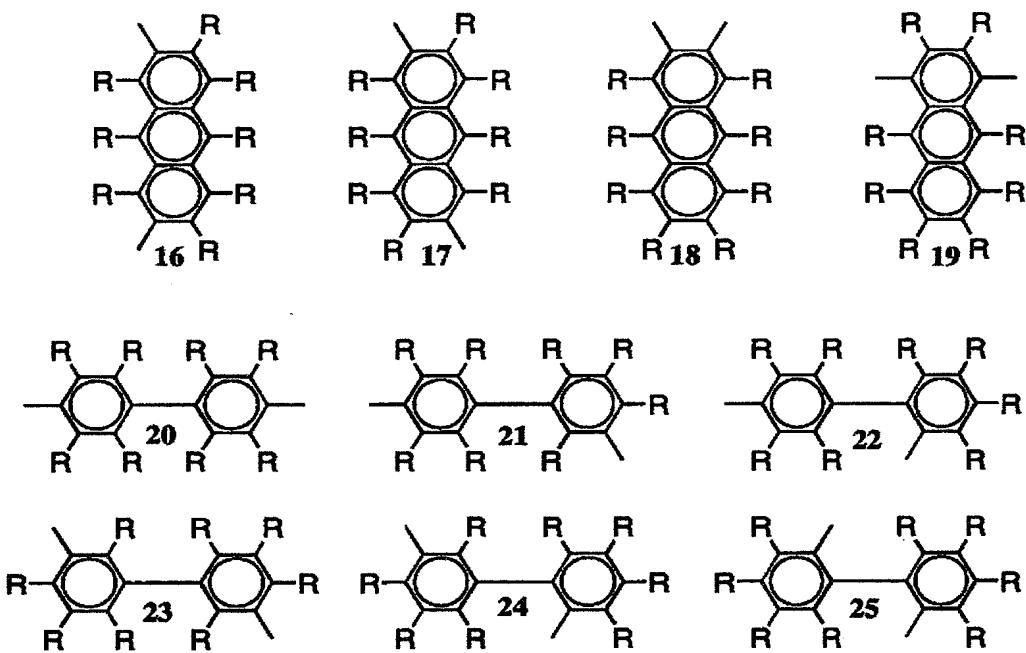
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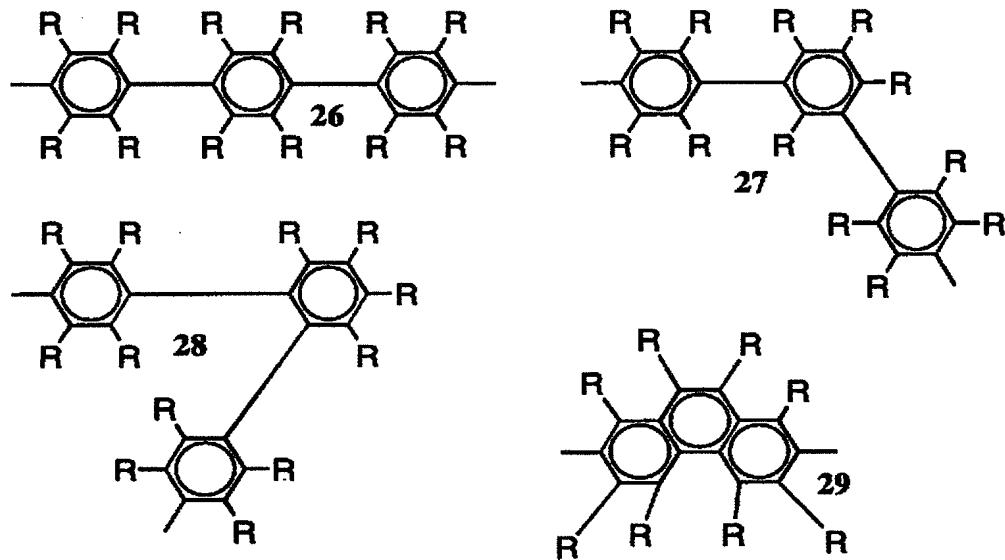
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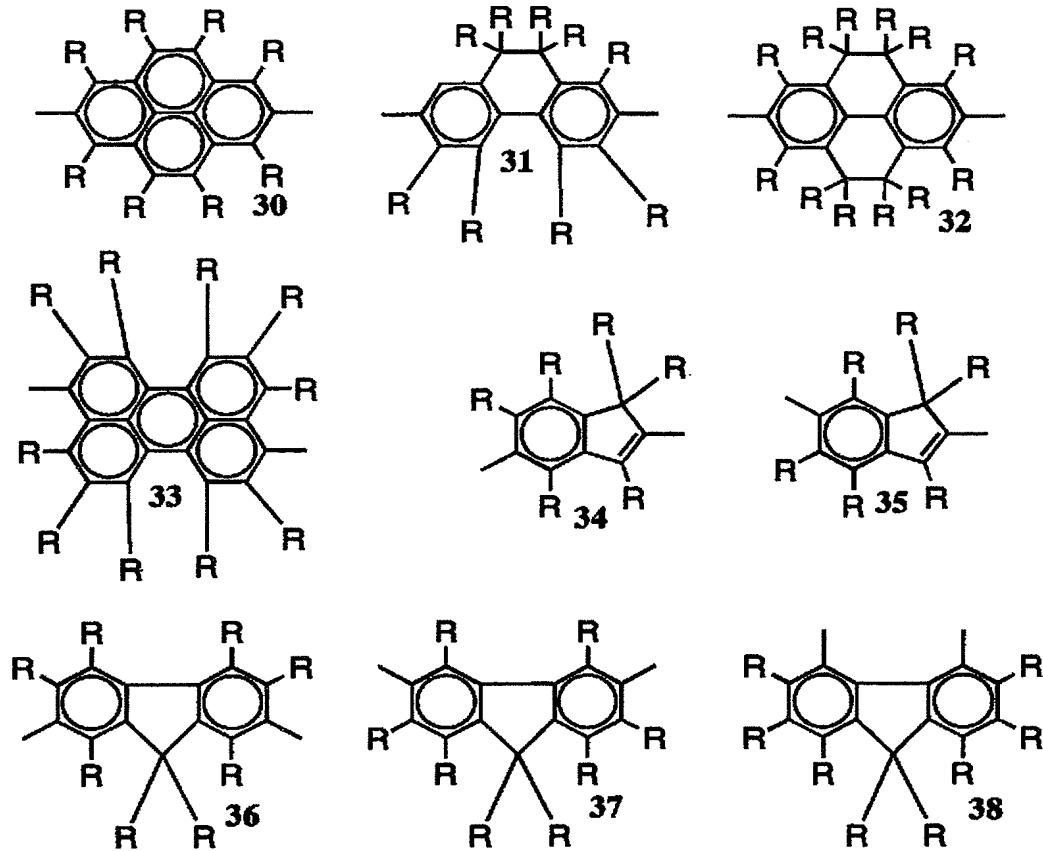
[0035]



[0036]



[0037]



[0038]

A divalent heterocyclic group in Ar_1 and Ar_2 in
Formula (1) is a remaining atomic group after removing 2
5 hydrogen atoms from a heterocyclic compound, and the
number of carbon atoms is normally 3 to about 60.

The term "heterocyclic compound" used herein
means an organic compound having a cyclic structure
wherein atoms constituting the ring are not only carbon
10 atoms, but also hetero atoms, such as oxygen, sulfur,
nitrogen, phosphorus, boron and arsenic, are contained
in the ring.

[0039]

The specific examples of divalent heterocyclic groups are as follows:

Divalent heterocyclic groups containing

- 5 nitrogen as a hetero atom: pyridine-diyl groups
(following Formulas 39 to 44), diazaphenylene groups
(following Formulas 45 to 48), quinoline-diyl groups
(following Formulas 49 to 63), quinoxaline-diyl groups
(following Formulas 64 to 68), acridine-diyl groups
- 10 (following Formulas 69 to 72), bipyridyl-diyl groups
(following Formulas 73 to 75), phenanthroline-diyl groups
(following Formulas 76 to 78) and the like.

Groups having a fluorene structure containing silicon, nitrogen, sulfur, selenium or the like as a
15 hetero atom (following Formulas 79 to 93).

Five-membered ring heterocyclic groups containing silicon, nitrogen, sulfur, selenium or the like as a hetero atom (following Formulas 94 to 98) are included.

20 Five-membered ring condensed heterocyclic groups containing silicon, nitrogen, sulfur, selenium or the like as a hetero atom (following Formulas 99 to 110) are included.

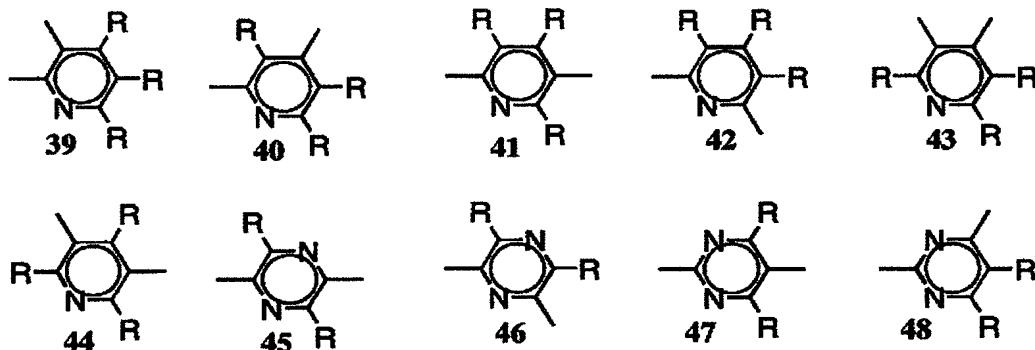
Five-membered ring heterocyclic groups containing silicon, nitrogen, sulfur, selenium or the like as a hetero atom, which bond at the α -position of the hetero atom to form a dimer or an oligomer (following Formulas 111 and 112) are included.

Five-membered ring heterocyclic groups containing silicon, nitrogen, sulfur, selenium or the like as a hetero atom, which bond to a phenyl group at the α -position of the hetero atom (following Formulas 5 113 to 119) are included.

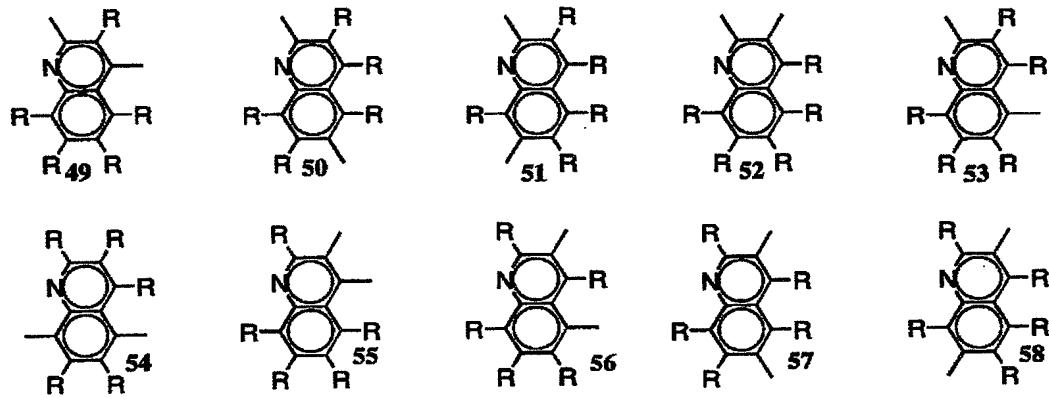
Five-membered ring condensed heterocyclic groups containing oxygen, nitrogen, sulfur or the like as a hetero atom, substituted by a phenyl group, a furyl group or a thienyl group (following Formulas 120 to 125) 10 are included.

Of these, heterocyclic groups containing nitrogen, oxygen or sulfur as a hetero atom are preferable; heterocyclic groups containing a furyl group (following Formulas 96, 124 and 125), heterocyclic groups containing a thienylene group (following Formulas 97, 111 to 113, 122 and 123), and heterocyclic groups containing a pyridine-2,5-diyl group (following Formula 41) are further preferable; and heterocyclic groups containing a thienylene group and a thienylene group 20 having a substituent are especially preferable.

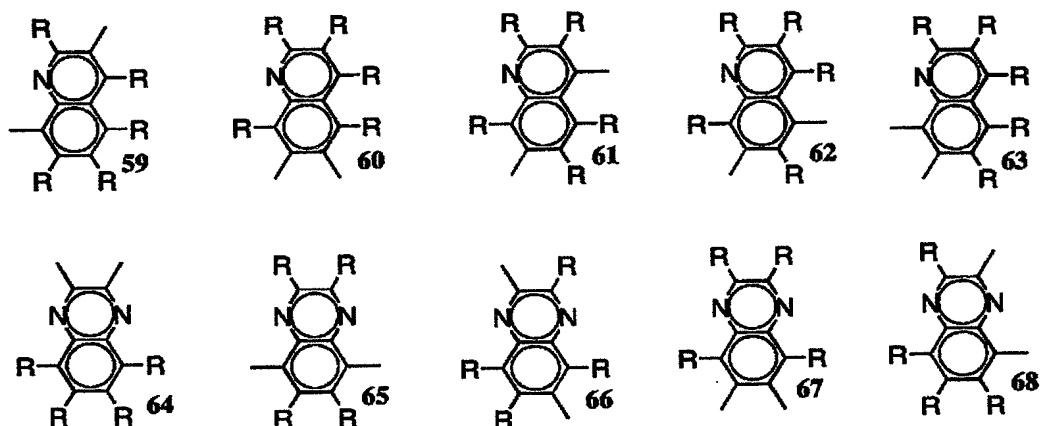
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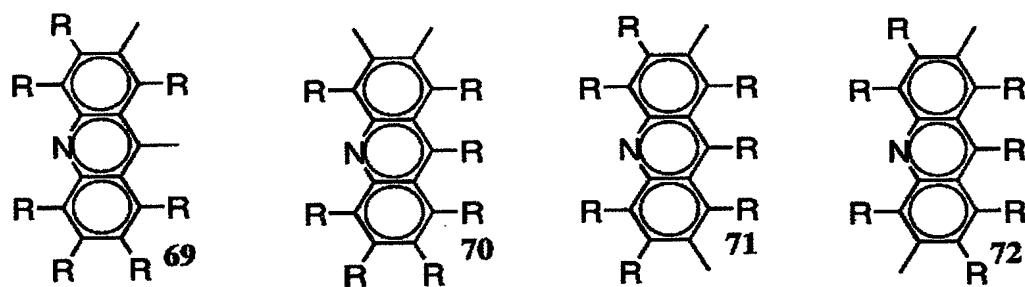
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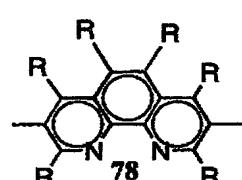
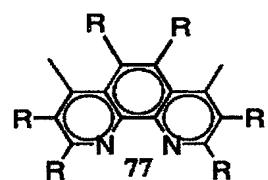
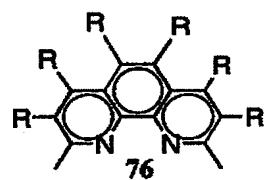
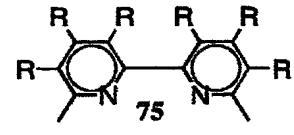
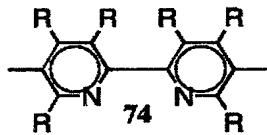
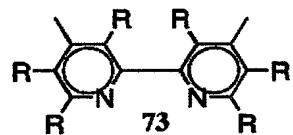
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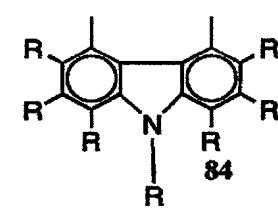
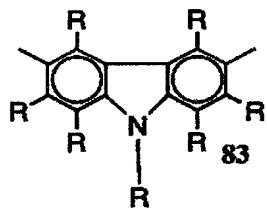
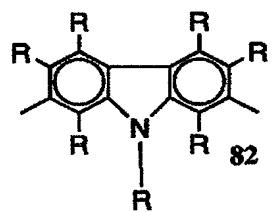
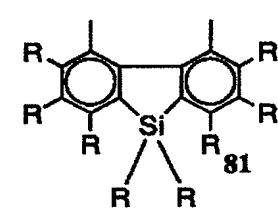
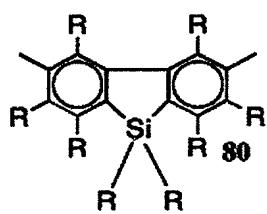
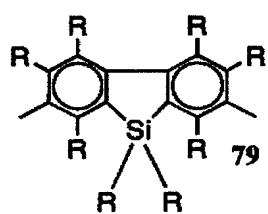
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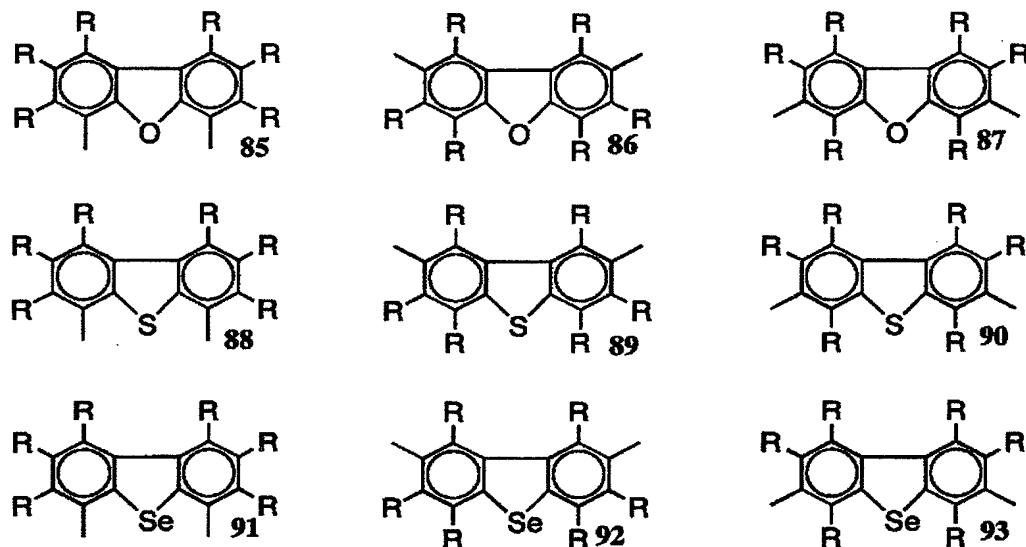
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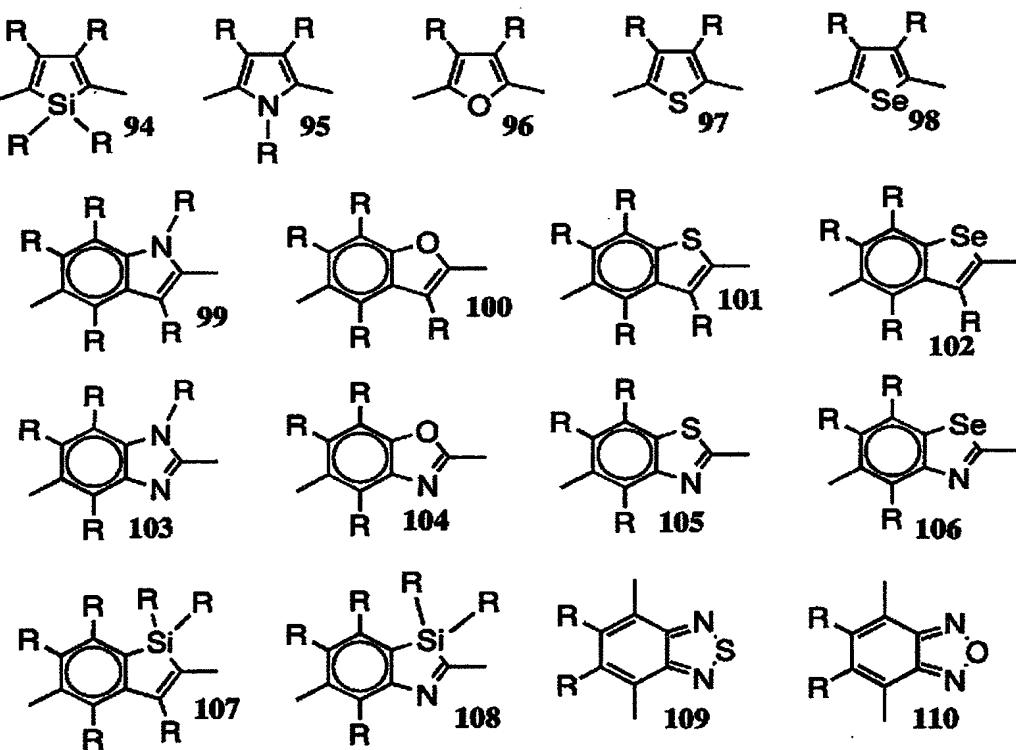
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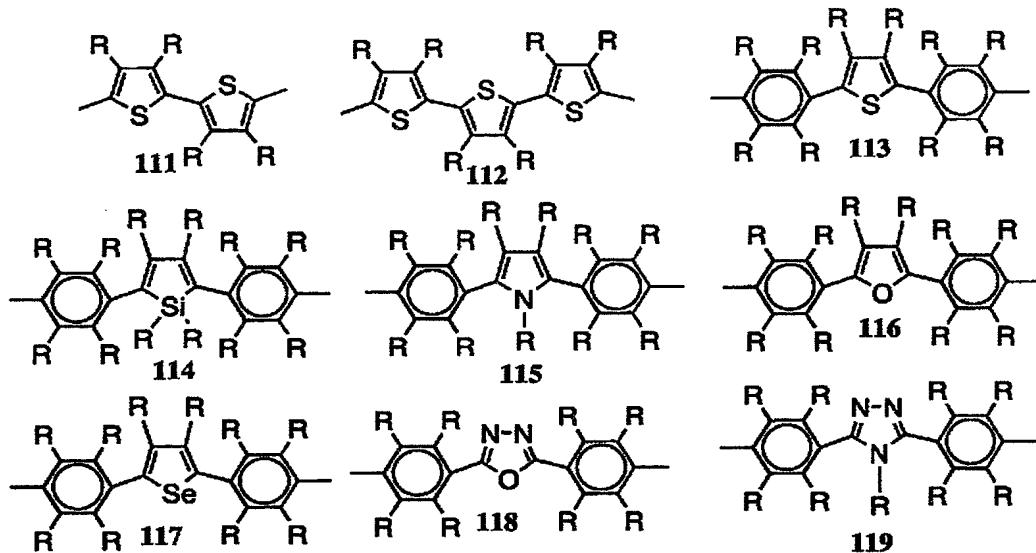
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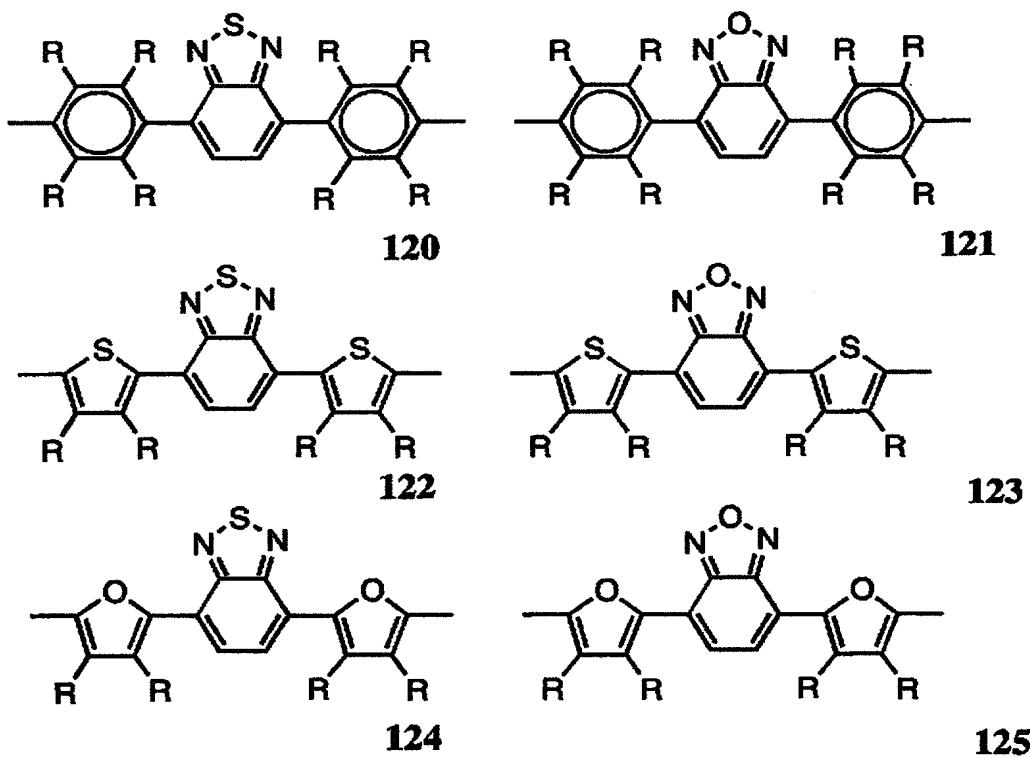
[0047]



[0048]



[0049]



(Here, each R in the formulas 1 to 125 independently represents a hydrogen atom, a cyano group, an alkyl group, an alkoxy group, an alkylthio group, an aryl group, an aryloxy group, or a monovalent heterocyclic group. When a plurality of R's are present, they can be identical or different.)

5 [0050]

In the substituents in Ar_1 and Ar_2 , the alkyl group is linear, branched or cyclic, usually has about 10 to 20 carbon atoms, and specifically, a methyl group, ethyl group, n-propyl group, iso-propyl group, n-butyl group, iso-butyl group, tert-butyl group, pentyl group, hexyl group, heptyl group, octyl group, nonyl group, decyl group, lauryl group, cyclopropyl group, cyclobutyl group, cyclopentyl group, cyclohexyl group, cycloheptyl group, cyclooctyl group, cyclononyl group, and cyclododecyl group can be cited, among which a pentyl group, hexyl group, octyl group, decyl group, and cyclohexyl group are preferable.

20 [0051]

The alkoxy group has usually about 1 to 20 carbon atoms, and the alkyl part thereof is linear, branched or cyclic. Specifically, examples include a methoxy group, ethoxy group, n-propyloxy group, iso-propyloxy group, n-butoxy group, iso-butoxy group, tert-butoxy group, pentyloxy group, hexyloxy group, heptyloxy group, octyloxy group, nonyloxy group, decyloxy group, lauryloxy group, cyclopropyloxy group, cyclobutyloxy

group, cyclopentyloxy group, cyclohexyloxy group, and cycloheptyloxy group, among which a pentyloxy group, hexyloxy group, octyloxy group, decyloxy group, and cyclohexyloxy group are preferable.

5 [0052]

The alkylthio group has usually about 1 to 20 carbon atoms, and the alkyl part thereof is linear, branched or cyclic. Examples include a methylthio group, ethylthio group, n-propylthio group, iso-propylthio group, n-butylthio group, iso-butylthio group, tert-butylthio group, pentylthio group, hexylthio group, heptylthio group, octylthio group, nonylthio group, decylthio group, laurylthio group, cyclopropylthio group, cyclobutylthio group, cyclopentylthio group, cyclohexylthio group, and cycloheptylthio group, among which a pentylthio group, hexylthio group, octylthio group, decylthio group, and cyclohexylthio group are preferable.

[0053]

20 Examples of aryl groups include a phenyl group, 4-C₁ to C₁₂ alkoxyphenyl group (C₁ to C₁₂ means that the number of carbon atoms is 1 to 12, the same applies to the followings), 4-C₁ to C₁₂ alkylphenyl group, 1-naphthyl group and 2-naphthyl group.

25 [0054]

Examples of monovalent heterocyclic groups include 2-thienyl group, 2-pyrrolyl group, 2-furyl group, and 2-, 3- or 4-pyridyl group.

[0055]

The substituent in Ar_1 and Ar_2 is preferably an alkoxy group.

[0056]

5 From the viewpoint of the solubility of polymer semiconductors to organic solvents, either one or both of Ar_1 and Ar_2 have preferably two or more substituents, and all of these substituents are preferably different. When substituents having the same 10 number of carbon atoms are compared, concerning alkyl groups, branched substituents are more preferable than linear ones.

[0057]

X_1 in Formula (1) represents $-CR_1=CR_2-$, $-C\equiv C-$ 15 or $-N(R_3)-$, and $-CR_1=CR_2-$ and $-N(R_3)-$ are preferable. Each of R_1 and R_2 independently represents a hydrogen atom, an alkyl group, an aryl group, a monovalent heterocyclic group, a carboxyl group, a substituted 20 carboxyl group or a cyano group; R_3 represents a hydrogen atom, an alkyl group, an aryl group, a monovalent heterocyclic group, an arylalkyl group or a substituted amino group. When R_3 is an aryl group, a monovalent heterocyclic group or an arylalkyl group, it can further have a substituted amino group.

25 [0058]

Here, the alkyl group is linear, branched or cyclic, the number of carbon atoms is normally 1 to about 20, and specifically, a methyl group, ethyl group,

n-propyl group, iso-propyl group, n-butyl group, iso-butyl group, tert-butyl group, pentyl group, hexyl group, heptyl group, octyl group, nonyl group, decyl group, lauryl group, cyclopropyl group, cyclobutyl group, cyclopentyl group, cyclohexyl group, cycloheptyl group, cyclooctyl group, cyclononyl group, and cyclododecyl group can be cited, among which a pentyl group, hexyl group, octyl group, decyl group, and cyclohexyl group are preferable.

10 [0059]

Examples of aryl groups include a phenyl group, 4-C₁ to C₁₂ alkoxyphenyl group, 4-C₁ to C₁₂ alkylphenyl group, 1-naphthyl group and 2-naphthyl group.

15 [0060]

Examples of monovalent heterocyclic groups include 2-thienyl group, 2-pyrrolyl group, 2-furyl group, and 2-, 3- or 4-pyridyl group.

A substituted carboxyl group has usually about 20 2 to 60 carbon atoms, preferably 2 to 48. The substituted carboxyl group means a carboxyl group substituted by an alkyl group, an aryl group, an arylalkyl group or a monovalent heterocyclic group; and examples of substituted carboxyl groups include a 25 methoxycarbonyl group, ethoxycarbonyl group, propoxycarbonyl group, i-propoxycarbonyl group, butoxycarbonyl group, i-butoxycarbonyl group, t-butoxycarbonyl group, pentyloxycarbonyl group,

hexyloxycarbonyl group, cyclohexyloxycarbonyl group,
heptyloxycarbonyl group, octyloxycarbonyl group, 2-ethyl
hexyloxycarbonyl group, nonyloxycarbonyl group,
decyloxycarbonyl group, 3,7-dimethyl octyloxycarbonyl
5 group, docecyloxycarbonyl group,
trifluoromethoxycarbonyl group,
pentafluoroethoxycarbonyl group, perfluorobutoxycarbonyl
group, perfluorohexyloxycarbonyl group,
perfluoroctyloxycarbonyl group, phenoxy carbonyl group,
10 naphthoxycarbonyl group, and pyridyloxycarbonyl group.
The alkyl group, aryl group, arylalkyl group or
monovalent heterocyclic group can have a substituent.
The number of carbon atoms in the substituted carboxyl
group does not contain the number of carbon atoms in the
15 substituent.

[0061]

The arylalkyl group has normally 7 to about
60, preferably 7 to 48 carbon atoms. Specifically,
examples of arylalkyl groups include a phenyl-C₁ to C₁₂
20 alkyl group, C₁ to C₁₂ alkoxyphenyl-C₁ to C₁₂ alkyl group,
C₁ to C₁₂ alkylphenyl-C₁ to C₁₂ alkyl group, 1-naphthyl-C₁
to C₁₂ alkyl group, and 2-naphthyl-C₁ to C₁₂ alkyl group;
and the C₁ to C₁₂ alkoxyphenyl-C₁ to C₁₂ alkyl group and C₁
to C₁₂ alkylphenyl-C₁ to C₁₂ alkyl group are preferable.

25 [0062]

Examples of substituted amino groups include
amino groups substituted by one or two groups selected
from a group consisting of an alkyl group, aryl group,

arylalkyl group and monovalent heterocyclic group, and the alkyl group, aryl group, arylalkyl group and monovalent heterocyclic group can further have a substituent. The number of carbon atoms in the 5 substituted amino group not including carbon atoms in the substituent is usually about 1 to 60, preferably 2 to 48.

The specific examples of substituted amino groups include a methylamino group, dimethylamino group, 10 ethylamino group, diethylamino group, propylamino group, dipropylamino group, i-propylamino group, diisopropylamino group, butylamino group, i-butylamino group, t-butylamino group, pentylamino group, hexylamino group, cyclohexylamino group, heptylamino group, 15 octylamino group, 2-ethyl hexylamino group, nonylamino group, decylamino group, 3,7-dimethyl octylamino group, laurylamino group, cyclopentylamino group, dicyclopentylamino group, cyclohexylamino group, dicyclohexylamino group, pyrrolidyl group, pyperidyl group, 20 di-trifluoromethylamino group, phenylamino group, diphenylamino group, C₁ to C₁₂ alkoxyphenylamino group, di-(C₁ to C₁₂ alkoxyphenyl)-amino group, di-(C₁ to C₁₂ alkylphenyl)-amino group, 1-naphthylamino group, 2-naphthylamino group, pentafluoro phenylamino group, 25 pyridylamino group, pyridazinylamino group, pyrimidylamino group, pyrazylamino group, triazylamino group, phenyl-C₁ to C₁₂ alkylamino group, C₁ to C₁₂ alkoxyphenyl-C₁ to C₁₂ alkylamino group, C₁ to C₁₂

alkylphenyl-C₁ to C₁₂ alkylamino group, di-(C₁ to C₁₂ alkoxyphenyl-C₁ to C₁₂ alkyl)-amino group, di-(C₁ to C₁₂ alkylphenyl-C₁ to C₁₂ alkyl)-amino group, 1-naphthyl-C₁ to C₁₂ alkylamino group, and 2-naphthyl-C₁ to C₁₂ alkylamino group.

5 group.

[0063]

Examples of repeating units represented by Formula (1) include:

—Ar₁— (2)

—X₁— (3)

—Ar₁—X₁— (4)

—Ar₁—Ar_{1'}—Ar₂— (5)

—Ar₁—X₁—Ar₂— (6)

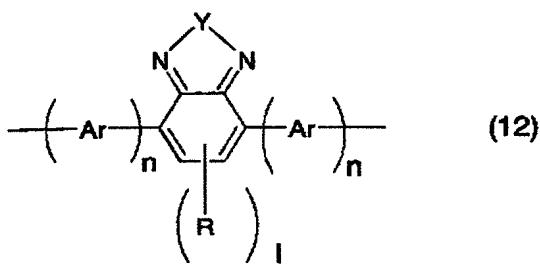
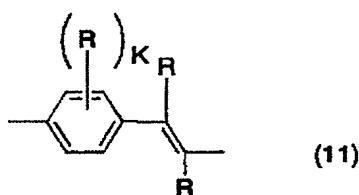
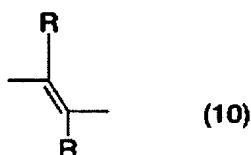
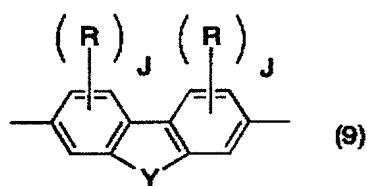
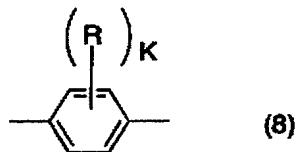
—Ar₁—X₁—Ar₁—X₁—Ar₂— (7)

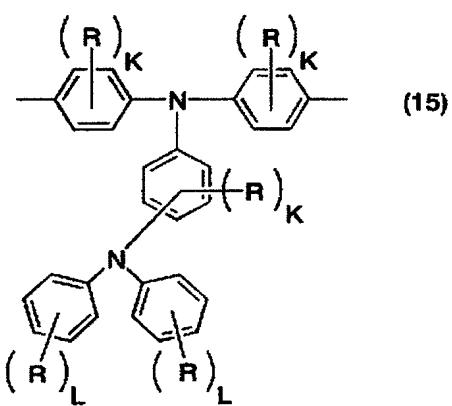
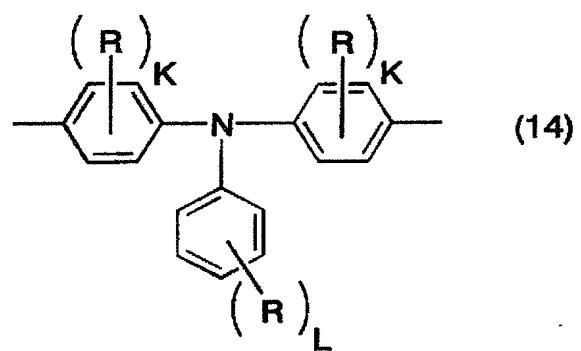
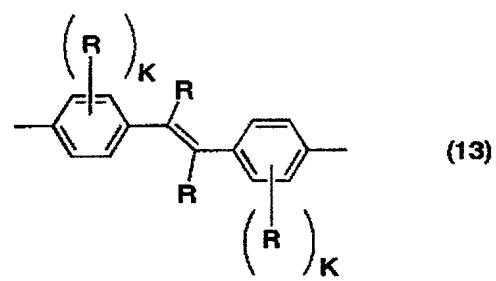
wherein Ar₁, Ar₂ and X₁ are the same as those in Formula 10 (1).

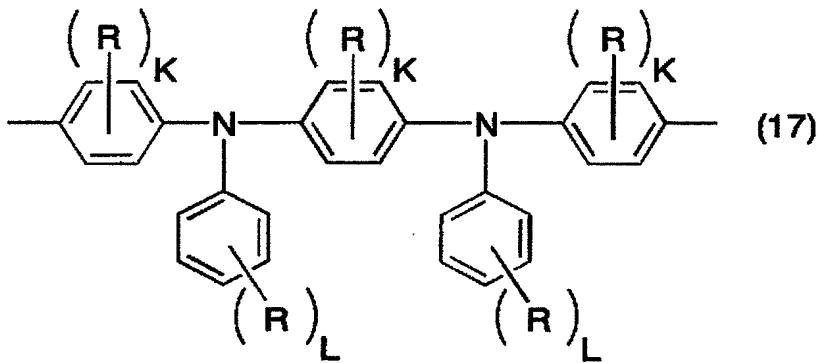
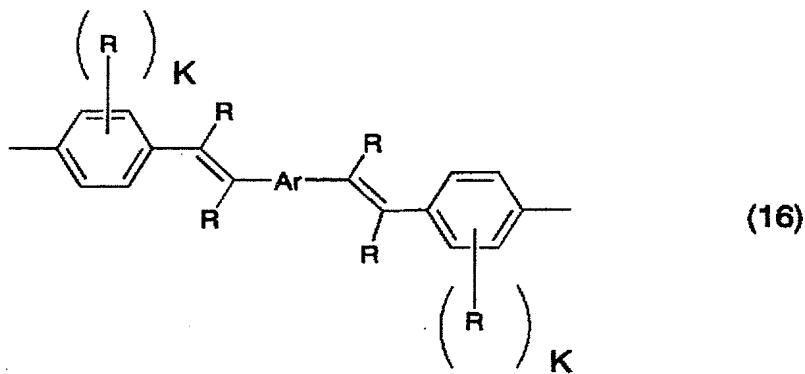
[0064]

The specific examples of Formula (2) are the following Formulas (8) and (9); the specific example of Formula (3) is the following Formula (10); the specific 15 example of Formula (4) is the following formula (11); the specific example of Formula (5) is the following

formula (12); the specific examples of Formula (6) are the following Formulas (13), (14) and (15); and the specific examples of Formula (6) are the following Formulas (16) and (17).







(where Ar represents an arylene group or a divalent heterocyclic group; and R represents a hydrogen atom, a cyano group, an alkyl group, an alkoxy group, an alkylthio group, an aryl group, an aryloxy group, or a 5 monovalent heterocyclic group. When a plurality of R's are present, they can be same or different. Y represents O, S, SO₂, Se, Te, N-R', CR'R" or SiR'R"; where each of R' and R" represents an alkyl group, an alkoxy group, an aryl group, a monovalent heterocyclic 10 group or an arylalkyl group; n represents an integer of 0 or 1; I represents an integer from 0 to 2; J represents an integer from 0 to 3; K represents an integer from 0 to 4; and L represents an integer from 0

to 5.)

[0065]

When a polymer semiconductor used in the present invention has a repeating unit represented by

5 Formula (1), the polymer semiconductor can be a random, block or graft copolymer containing two or more kinds of repeating units represented by Formula (1), or can be a polymer semiconductor having an intermediate structure thereof, for example, a random copolymer with some

10 characteristics of a block copolymer. From the viewpoint of obtaining an organic light-light conversion element having excellent properties, the random copolymer with some characteristics of a block copolymer, or a block or graft copolymer is more

15 preferable than a perfect random copolymer. The case wherein the main chain is branched, or the case wherein there are 3 or more end portions is also included.

[0066]

Although the end group of the polymer semiconductor used in the present invention is not specifically limited, if a polymerization activating group remains intact, there is possibility that the characteristics are lowered when it is used in an active layer; therefore, the polymer semiconductor is

25 preferably protected by a stable group. The polymer semiconductor having a conjugated bond continued from the conjugated structure of the main chain is more preferable, and an example is a structure bonded to an

aryl group or a heterocyclic group through a vinylene group. Specifically, the substituent represented by Formula 10 in JP-A-9-45478 and the like are exemplified.

[0067]

5 The polystyrene-converted number average molecular weight of the polymer semiconductor used in the present invention is normally 1×10^3 to 1×10^8 . If the molecular weight is excessively low, obtaining a homogeneous thin film tends to be difficult; and if the 10 molecular weight is excessively high, the polymer semiconductor tends to be gelled, and thin film formation tends to be difficult. From the aspect of film formation, the number average molecular weight is preferably 1×10^4 to 2×10^7 , more preferably 1×10^5 to 15 1×10^7 .

[0068]

Examples of favorable solvents for the polymer semiconductor include chloroform, methylene chloride, dichloroethane, tetrahydrofuran, toluene, xylene, 20 mesitylene, decalin, n-butyl benzene and the like. Depending on the structure or molecular weight of the polymer semiconductor, 0.1% by weight or more can be normally dissolved in these solvents.

[0069]

25 An example of methods for synthesizing the polymer semiconductor used in the present invention, when the main chain has vinylene groups, is the method described in JP-A-5-202355. Specifically, examples of

the methods include polymerization by the Wittig reaction, such as the polymerization of a dialdehyde compound with a diphosphonium salt compound, or the polymerization of a dialdehyde compound with a

5 diphosphite ester by the Horner-Wadsworth-Emmons method; the polymerization of a divinyl compound with a dihalide compound or vinyl-halogen compound alone by the Heck reaction; the polycondensation of a compound having two halogenated methyl groups by the dehalogenation method;

10 the polycondensation of a compound having two sulfonium salt groups by the sulfonium salt decomposition method; methods for the polymerization of a dialdehyde compound with a diacetonitrile compound by the Knoevenagel reaction or the like; and methods for the polymerization

15 of a dialdehyde compound by the McMurry reaction.

When the main chain has no vinylene groups, examples of the methods include a method for polymerization from a corresponding monomer by the Suzuki coupling reaction; a method for polymerization by

20 the Grignard reaction; a method for polymerization by $\text{Ni}(0)$ complex; a method for polymerization by an oxidant such as FeCl_3 ; a method for polymerization by electrochemical oxidation; and a method by the decomposition of an intermediate product having suitable

25 eliminating groups.

[0070]

Of these methods, polymerization by the Wittig reaction, polymerization by the Heck reaction,

polymerization by the Knoevenagel reaction, the method for polymerization by the Suzuki coupling reaction (WO 00/53656 and WO 00/55927), the method for polymerization by the Grignard reaction, and the method for 5 polymerization by nickel (0) complex are preferable because of easy control of the structure.

[0071]

When these polymer semiconductors are used in an organic light-light conversion element, since the 10 purity thereof affects the properties, it is preferable to perform purification treatment, such as reprecipitation purification and chromatographic isolation after the synthesis.

[0072]

15 In the device of the present invention, when a polymer semiconductor containing one or more repeating units represented by Formula (1) is used in the photo-current multiplication layer and the organic EL light emitting layer, one kind of the polymer semiconductor 20 containing one or more repeating units represented by Formula (1) can be used, or the mixture of two or more kinds of polymer semiconductors containing one or more repeating units represented by Formula (1) can also be used. Further, the mixture of polymers other than the 25 polymer semiconductor represented by Formula (1) can also be used within the range not inhibiting the properties of the organic light-light conversion element. Examples of polymers to be mixed include

general purpose polymers, such as polycarbonate, polyvinyl butyral, polyvinyl alcohol, polystyrene and polymethyl methacrylate, and conductive polymers, such as polyvinyl carbazole and polysilane.

5 At this time, the proportion of the polymer semiconductor represented by Formula (1) is within the range between 10% and 100%, more preferably within the range between 30% and 100%, and further preferably within the range between 50% and 100%.

10 [0073]

By two-dimensionally arranging a plurality of organic light-light conversion devices according to the present invention, an image intensifier to sense weak light invisible to the naked eye or light other than 15 visible light, such as infrared beams and ultraviolet beams in the light sensing unit, and output it as visible light (i.e. image) from the light emitting unit can be constituted. Depending on applications, one-dimensional arrangement is also effective.

20 [0074]

The voltage applied to the device of the present invention is distributed into the light sensing unit and the light emitting unit. Since the number of electrons formed in the photo-current multiplication 25 layer is increased and the electrical resistance of the light sensing unit is lowered when the intensity of incident light to the light sensing unit is larger, the voltage distributed to the light emitting unit is

raised, and intensity of the outgoing light is enlarged.

In the organic light-light conversion device of the present invention, since the voltage distributed to the light emitting unit can be easily measured, the 5 value of the voltage from the light emitting unit can be used as the electrically signalized intensity of the incident light and the outgoing light. Thereby, the device can be used as a light sensor that detects the intensity of the incident light as electrical signals. 10 Since the value of thus outputted voltage corresponds to the quantity of incident light, the device functions as a light sensor.

Specifically, the light sensor of the present invention is characterized in having an organic light-light conversion device and means for measuring and outputting the voltage across both ends of the layer containing an electroluminescent organic semiconductor (organic EL light emitting layer). Furthermore, the device can emit light, for example, by some electricity-light conversion from the exterior where the above-described electrical signals are received while emitting light from the light emitting unit.

[Examples]

[0075]

25 Examples for describing the present invention in further detail will be shown below; however, the present invention is not limited thereto.

Here, the polystyrene-converted number average

molecular weight was obtained using a gel permeation chromatography (GPC) method as follows:

Using a column: Pl gel mix-B + mix-C (8 mm I.d. × 30 cm); and a sensor: RI (Shodex RI-101), 50 µl
5 of a chloroform solution of a polymer adjusted to have a concentration of 1.0 mg/ml was injected, and measurement was performed under the chloroform flow rate condition of 1.0 ml/min.

[0076]

10 Example 1

<Synthesis of polymer semiconductor>

Poly(9,9-dioctylfluorene) (PFO) was synthesized using the method described in WO 00/53656. The number average molecular weight of the PFO was $4.8 \times 15 10^4$. Poly(2,7-(9,9-dioctylfluorene)-alt-(1,4-phenylene((4-sec-butylphenyl)imino)-1,4-phenylene)) (TFB) was synthesized using the method described in WO 00/55927. The number average molecular weight of the TFB was 1.8×10^4 .

20 [0077]

<Fabrication of organic light-light conversion device>

On a glass substrate with a patterned ITO film, the suspension of poly(3,4-ethylene dioxythiophene/polystyrene sulfonic acid PEDOT) (Bytron 25 P TP AI 4083 manufactured by Bayer) was applied by spin coating to form a film, and after peeling the film leaving a part on the ITO, the film was dried on a hot plate at 200°C for 10 minutes. Onto the film, a solution

prepared by mixing toluene solutions of PFO and TFB in the weight ratio of 6:4 and filtering with a 0.2- μ m filter was applied by spin coating to form a thin polymer semiconductor film. The thin polymer

5 semiconductor film other than the area on the PEDOT was peeled, and set in a vacuum vapor deposition apparatus. An MgAg film having a thickness of 30 nm was formed as a cathode by co-deposition method at a speed of 5:0.5 angstroms/sec on the remaining thin polymer

10 semiconductor film using a shadow mask. An Ag film having a thickness of 20 nm was formed thereon at a speed of 0.6 angstroms/sec to form a light emitting unit. The shadow mask was moved, the PEDOT and thin polymer semiconductor film was peeled, and a film of a

15 photo-conductive organic semiconductor, naphthalene tetracarboxylic dianhydride (NTCDA) having a thickness of 600 nm was formed on the part where the ITO was exposed at a speed of 2.5 angstroms/sec. An Au film having a thickness of 20 nm was formed thereon as an

20 electrode at a speed of 0.4 angstroms/sec to form a light sensing unit.

[0078]

<Characteristic evaluation of organic light-light conversion device>

25 Fig. 2 shows a sectional view of a coplanar-type organic light-light conversion device according to the present invention. A direct current source 27 was connected to the electrode 23 of the light sensing unit

and the electrode 26 of the light emitting unit as Fig. 2 shows, and a voltage V_a was applied between the light sensing unit 31 and the light emitting unit 32 from the direct current source 27. As described below, for the 5 purpose of checking the characteristics of the device, several values of the voltages V_a between 5 and 30 V were used. In the state wherein the voltage V_a was applied between the light sensing unit 31 and the light emitting unit 32, incident light 28 of a wavelength of 10 400 nm and an intensity of $56 \mu\text{W}/\text{cm}^2$ was radiated from the surface of the electrode 23 to the light sensing unit 31. As a result, outgoing light 29 of a wavelength of 450 nm was obtained from the substrate 21 side of the light emitting unit 32. The wave length of the incident 15 light 28 was different from the wave length of the outgoing light 29, and wavelength conversion, which is one of the characteristics of the light-light conversion device, was performed. Depending on the selection of materials for the organic EL light emitting layer 24, 20 outgoing light of further different colors can also be obtained.

[0079]

Fig. 3 shows the results of the intensities of the outgoing light 29 in the case wherein the applied 25 voltage V_a was 5 to 30 V measured by a light sensor 33 using a photodiode. In the measurement, the radiation of incident light 28 was started 30 seconds after starting the application of the direct current source

27, and the radiation of incident light 28 was stopped 60 seconds after starting the radiation of incident light 28. The intensities of the outgoing light 29 were changed by the ON/OFF of the incident light 28.

5 [0080]

From Fig. 3, it is known that the light emitting unit continues outputting light even after stopping the radiation of incident light. This is due to the above-described light feedback effect. In this 10 example, no operations for suppressing the light feedback effect were performed in order to strengthen the intensity of the outgoing light. When importance is placed on the response to the incident light, the inflow of feedback light 35 into the light sensing unit 31 can 15 be suppressed, for example, by the method of lengthening the distance 36 between the light sensing unit 31 and the light emitting unit 32 as Fig. 4 shows; or the method of installing a light-shielding member 37 between the light sensing unit 31 and the light emitting unit 32 20 as Fig. 5 shows. Although the above-described light-shielding member 37 can completely shield the feedback light 35, when the effect of light amplification by light feedback is also desired to obtain, a member having a transmittance that suppresses but does not 25 completely shield the flow of the feedback light into the light sensing unit (translucent member) can be used.

[0081]

Next, the efficiency of light-light conversion

from incident light to outgoing light will be described. This is defined by the value obtained by dividing the number of photons outputted as outgoing light by the number of photons inputted as incident light. If the 5 value is less than 1, there is light loss during conversion; and if the value exceeds 1, the outgoing light more than incident light is obtained. The results are represented by Fig. 6. When V_a is 25 V, 280 times light-light conversion efficiency was obtained.

10 [0082]

Example 2

<Fabrication of organic light-light conversion device>

On a glass substrate with a patterned ITO film, the suspension of PEDOT is applied by an ink-jet 15 method to form a thin PEDOT film on a part of the ITO film, and dried on a hot plate at 200°C for 10 minutes. Decalin solutions of PFO and TFB are mixed in a weight ratio of 6:4, and filtered using a 0.2- μ m filter. The filtered solution is applied onto the thin PEDOT film by 20 an ink-jet method to form a light emitting unit region. Then, a thin polymer semiconductor film is formed on the area of the ITO film where no PEDOT film is formed by an ink-jet method using a decalin solution of PFO filtered by a 0.2- μ m filter to form a light sensing unit region. 25 The substrate is set in a vacuum vapor deposition apparatus, and an MgAg film having a thickness of 30 nm is formed as a cathode by co-deposition method at a speed of 5:0.5 angstroms/sec on the light emitting

region using a shadow mask. An Ag film having a thickness of 20 nm is formed thereon at a speed of 0.6 angstroms/sec. The shadow mask is moved, and an Au film having a thickness of 20 nm is formed thereon as an 5 electrode at a speed of 0.4 angstroms/sec.

[0083]

<Characteristic evaluation of organic light-light conversion device>

In the same manner as in Example 1, incident 10 light 28 of a wavelength of 400 nm and an intensity of 56 $\mu\text{W}/\text{cm}^2$ is radiated while applying voltage V_a between the light sensing unit and the light emitting unit. As a result, outgoing light of a wavelength of 450 nm is obtained from the substrate side of the light emitting 15 unit, and the wavelength is converted. The light-light conversion efficiency from incident light to outgoing light at this time exceeds 10 times, and light amplification can be confirmed.

[Brief Description of the Drawings]

20 [0084]

[Fig. 1]

Fig. 1 is a sectional view showing a configuration example of a light-light conversion device of the present invention.

25 [Fig. 2]

Fig. 2 is a sectional view showing an example of a light-light conversion device of the present invention.

[Fig. 3]

Fig. 3 is a graph showing change in the intensity of incident light by the outgoing light irradiation of a light-light conversion device of the 5 example represented by Fig. 2.

[Fig. 4]

Fig. 4 is a diagram showing an example of the method for suppressing the light feedback effect by controlling the distance between the light sensing unit 10 and the light emitting unit in a light-light conversion device of the present invention.

[Fig. 5]

Fig. 5 is a diagram showing an example of the method for suppressing the light feedback effect by 15 using a light shielding material in a light-light conversion device of the present invention.

[Fig. 6]

Fig. 6 is a graph showing light-light conversion efficiencies of a light-light conversion 20 device of the example represented by Fig. 2.

[Description of Reference Numerals]

[0085]

11, 21 ... substrate

12, 22 ... photo-current multiplication layer

13, 23 ... electrode of the light sensing unit

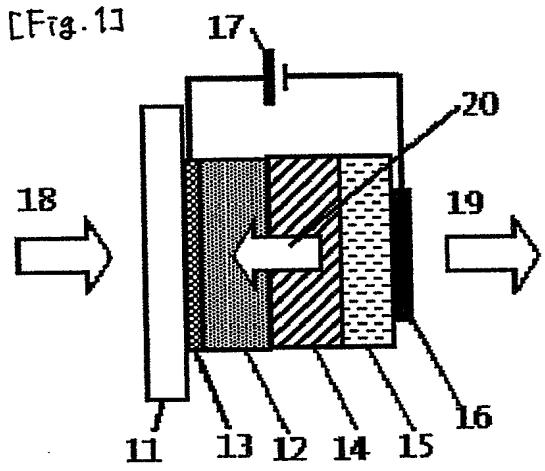
14, 24 ... organic EL light emitting layer

15, 25 ... hole transporting layer

16, 26 ... electrode of the light emitting unit
17, 27 ... direct current source
18, 28 ... incident light
19, 29 ... outgoing light
20, 35 ... feedback light
30 ... conductive layer to connect the light emitting
unit to the light sensing unit
31 ... light sensing unit
32 ... light emitting unit
33 ... light sensor
37 ... light-shielding member

【書類名】図面
【図1】

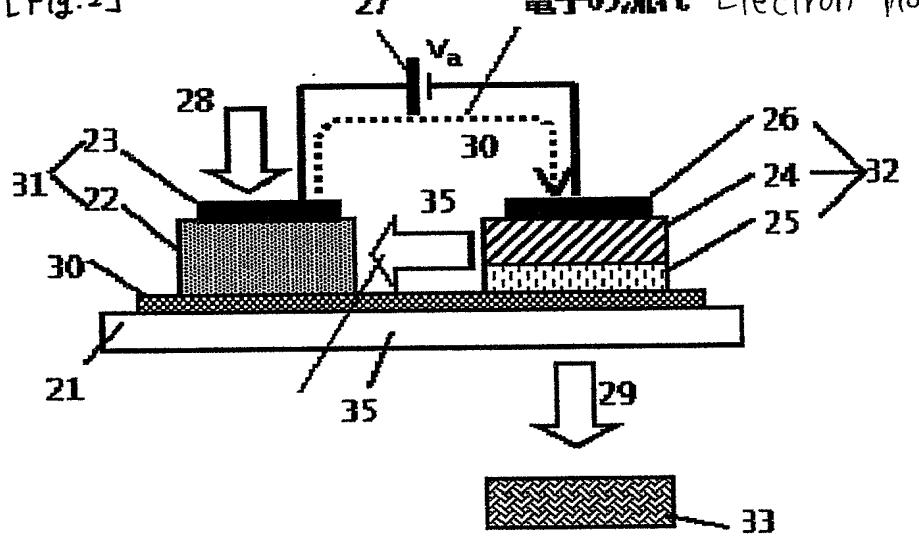
[Fig. 1]



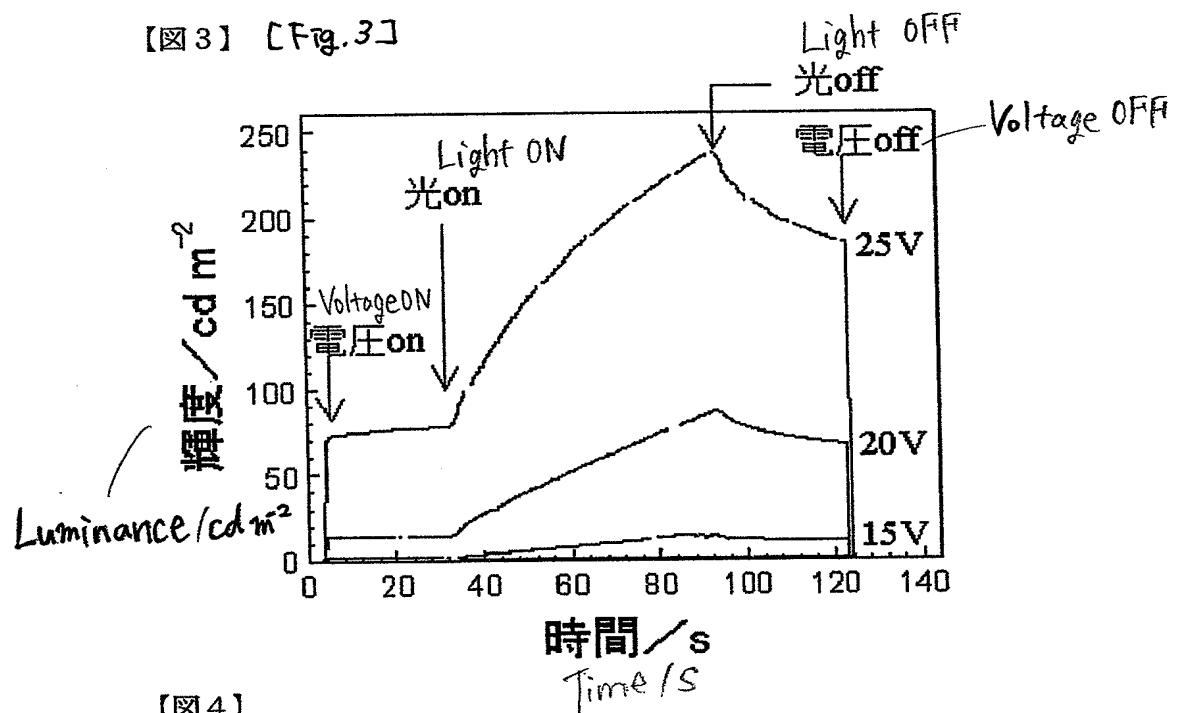
【図2】

[Fig. 2]

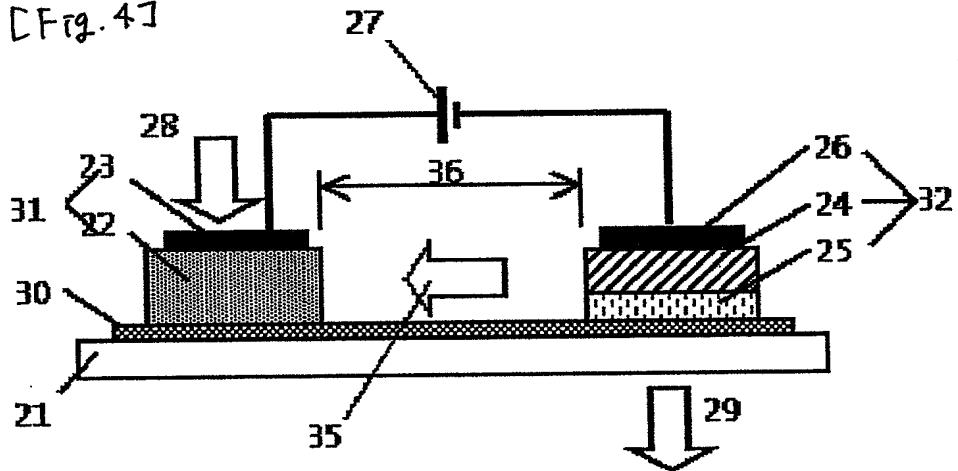
電子の流れ Electron flow



【図3】 [Fig. 3]

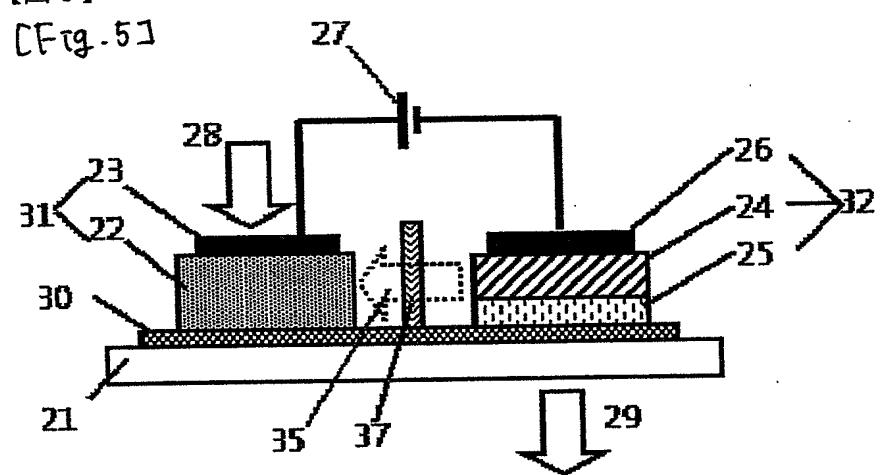


【図4】 [Fig. 4]

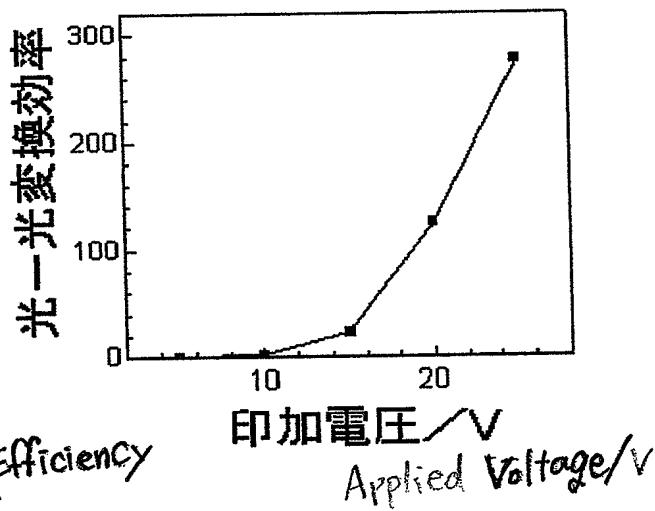


【図5】

[Fig. 5]



【図6】 [Fig. 6]



[Kind of Document] Abstract

[Abstract]

[Problem]

To provide an organic light-light conversion device excellent in device characteristics.

[Solution]

An organic light-light conversion device comprising:

a light sensing unit having a layer including a photo-conductive organic semiconductor developing a photo-current multiplication phenomenon by light irradiation, and a light emitting unit having a layer including an electroluminescent organic semiconductor emitting light by current injection, characterized in that

at least one of the photo-conductive organic semiconductor and an electroluminescent organic semiconductor is polymer semiconductor.

An imaging intensifier consisting of a plurality of arranged above organic light-light conversion devices.

An optical sensor provided with a means of measuring and outputting voltages applied to the above organic light-light conversion device and to the opposite ends of a layer including the electroluminescent organic semiconductor.

[Selected Drawing] None